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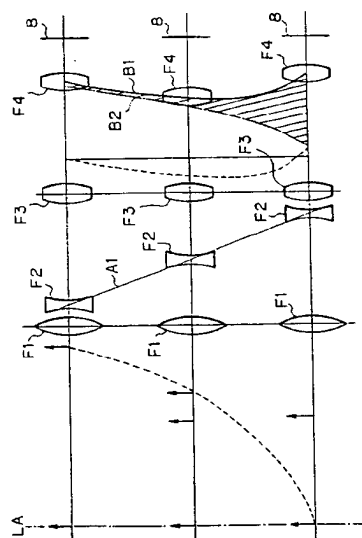
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(54) **A zoom tracking apparatus.**

(57) A zoom tracking apparatus of a focusing lens in which a position of a focusing lens is controlled to an infocus position so as to follow a motion of a zoom lens, comprises : means for oscillating the focusing lens or an image pickup device in the front and back directions ; and means for controlling front and back oscillating amounts of the focusing lens or the image pickup device, wherein the front and back oscillating amounts of the focusing lens or the image pickup device are changed in accordance with a relation between the position of the zoom lens and the infocus position of the focusing lens.

Fig. 3



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The invention relates to a zoom tracking apparatus of, for example, an inner focusing lens for controlling the position of the focusing lens to an infocus position so as to follow the motion of the zoom lens in a manner such that a focal point does not deviate when the zoom lens is moved.

To reduce the size and weight of a video camera, an inner focusing lens is used in an optical system of the video camera. In the case of the inner focusing lens, a zoom lens and a focusing lens are arranged in a lens assembly and the zoom lens and the focusing lens can be moved by, an actuator such as stepping motor, linear motor, or the like.

In the optical system of the video camera, the position of the focusing lens is tracking controlled so as to follow the motion of the zoom lens in a manner such that the focal point does not deviate when the zoom lens is moved. In the case of the inner focusing lens, since the zoom lens and the focusing lens cannot be directly moved, it is difficult to execute such a tracking control by using a mechanical cam. Therefore, in the case of the inner focusing lens, by setting a driving amount of the focusing lens in accordance with the motion of the zoom lens, the tracking control is performed. Such a control is also called an electronic cam.

Subjects for a video camera tend to change position. Therefore, in the case of executing automatic focusing control of a video camera, it is necessary to control the position of the focusing lens in accordance with the motion of the object.

In an automatic focusing circuit of a video camera of the image processing system, the principle that an integrated level of middle and high frequency components in an image pickup signal is maximum at the infocus position is used so the middle and high frequency component level in the image pickup signal is detected and integrated over a predetermined focusing area and an evaluation value is obtained. The position of the focusing lens is controlled so that the evaluation value becomes maximum.

In the case of the automatic focusing circuit for a video camera of an image processing system, in order to control the in-focus position in correspondence to the motion of an object to be photographed, the focusing lens or the image pickup device is oscillated back and forth. A peak value of the evaluation values is detected, thereby controlling the position of the focusing lens in accordance with the motion of the object to be photographed.

As mentioned above, with an inner focusing lens, when the zoom lens is moved, it is necessary to tracking control the focusing lens in accordance with characteristics showing the relation between the position of the zoom lens and the in-focus position of the focusing lens. With an automatic focusing circuit in a video camera it is necessary to oscillate the focusing lens or the image pickup device forwards and back-

wards and to control the infocus position in correspondence to the motion of the object to be photographed.

Therefore, in the case of executing the automatic focusing control in a system using an inner focusing lens, when the zoom lens is moved, the tracking control and the oscillating control must be simultaneously performed and so complicated processes are necessary.

It is, therefore, an object of the invention to provide a zoom tracking apparatus for a focusing lens which can simultaneously execute the tracking control and the oscillating control by simple processes.

According to an aspect of the invention, there is provided a zoom tracking apparatus of a focusing lens in which a position of a focusing lens is controlled to an infocus position so as to follow a motion of a zoom lens, comprising:

means for oscillating the focusing lens or an image pickup device forwards and backwards; and

means for controlling forward and backward oscillating amounts of the focusing lens or the image pickup device,

wherein the forward and backward oscillating amounts of the focusing lens or the image pickup device are changed in accordance with the relation between the position of the zoom lens and the infocus position of the focusing lens.

The above, and other, objects, features and advantage of the present invention will become readily apparent from the following detailed description thereof which is to be read in connection with the accompanying drawings, in which:-

Fig. 1 is a block diagram of an example of a video camera to which the invention is applied;

Fig. 2 is a side elevational view of an example of a lens structure in the video camera to which the invention is applied;

Fig. 3 is a schematic diagram which is used in the explanation of an embodiment of the invention; and

Fig. 4 is a vector diagram which is used in the explanation of an embodiment of the invention.

An embodiment of the invention will be described hereinbelow with reference to the drawings.

Fig. 1 shows an example of a video camera to which the invention is applied. In Fig. 1, reference numeral 1 denotes a lens. As shown in Fig. 2, the lens 1 comprises: a fixed first lens group  $F_1$ ; a fixed third lens group  $F_3$ , a movable second lens group (focusing lens)  $F_2$ , and a movable fourth lens group (focusing lens)  $F_4$ .

The position of the second lens group  $F_2$  can be moved by a zoom driving motor 2. A zoom amount is detected by a zoom position detector 3. An output of the zoom position detector 3 is supplied to a system controller 14.

The position of the fourth lens group  $F_4$  can be

moved by a focusing driving motor 6. The focusing driving motor 6 is driven by a driver 15 on the basis of a control of the system controller 14. The position of the fourth lens group  $F_4$  is detected by a focusing position detector 7. An output of the focusing position detector 7 is supplied to the system controller 14.

When the second lens group  $F_2$  is moved, it is necessary to move the fourth lens group  $F_4$  so as to follow the motion of the second lens group  $F_2$  so that a focal point is not deviated. According to an embodiment of the invention, as will be explained in detail hereinafter, in order to obtain the in-focus position so as to follow the motion of the second lens group  $F_2$ , when the second lens group  $F_2$  is moved, front and back oscillating amounts are made variable when oscillating the fourth lens group  $F_4$ .

An oscillating amount of the fourth lens group  $F_4$  is previously obtained from the relation between the position of the second lens group  $F_2$  and the position of the fourth lens group  $F_4$  as an in-focus position. The oscillating amount data is stored into a table of an oscillating-amount memory 21.

An opening or closing operation of an iris ring 23 in the lens 1 is controlled by an iris driving motor 5. The opening or closing state of the iris ring 5 is detected by an iris position detector 4 comprising, for example, a Hall device. An output of the iris position detector 4 is supplied to the system controller 14.

An image of an object to be photographed which has been transmitted through the lens 1 is formed onto a photo sensitive surface of a CCD image pickup device 8. An image pickup signal based on the image to be photographed is generated from the CCD image pickup device 8.

An output of the CCD image pickup device 8 is supplied to a sample and hold circuit 9. An output of the sample and hold circuit 9 is supplied to an A/D converter 11 through an AGC circuit 10. An output of the CCD image pickup device 8 is converted into a digital signal by the A/D converter 11.

An output of the A/D converter 11 is supplied to a digital video signal processing circuit 12 and is also supplied to an optical detector 13.

The optical detector 13 forms an AF detection signal for automatic focusing, an AD detection signal for automatic exposure, and an AWB detection signal for automatic white balance. The AF detection signal is formed from an integrated level of middle and high frequency components in a luminance signal in a predetermined focusing area. The AF detection signal is set to an evaluation value when the automatic focusing control is executed. The AE detection signal is formed from a luminance signal level in a predetermined exposure area. The AWB detection signal is formed from a luminance signal level and a chroma signal level in a predetermined AWB detection area.

The optical detector 13 and the system controller 14 are bidirectionally connected through a serial inter-

face.

A lens driving signal is generated by the system controller 14 in accordance with the AF detection signal which is sent from the optical detector 13 to the system controller 14. The lens driving signal is supplied to the focusing driving motor 6 through the driver 15. Thus, the position of the fourth lens group  $F_4$  is controlled.

An iris control signal and an AGC control signal are generated by the system controller 14 in accordance with the AC detection signal which is sent from the optical detector 13 to the system controller 14. The iris control signal is supplied to the iris driving motor 5 through a driver 16. Thus, the iris ring 23 is opened or closed and a gain of an AGC circuit 10 is set in accordance with a level of an image pickup signal from the CCD image pickup device 8.

A gain control signal and generated by the system controller 14 in accordance with the AWF detection signal which is sent from the optical detector 13 to the system controller 14. The gains to each components of color signals are set in the digital video signal processing circuit 12 in accordance with the gain control signals.

A luminance signal and a chroma signal are processed by the digital video signal processing circuit 12. The processed luminance signal and the chroma signal are converted into analog signals through D/A converters 19A and 19B, respectively, and are output from output terminals 20A and 20B.

Fig. 2 shows a structure of the lens 1 of the video camera to which the invention is applied. The lens 1 is constructed as an inner focusing lens such that the first lens group  $F_1$  and the third lens group  $F_3$  are fixed and the second lens group  $F_2$  and the fourth lens group  $F_4$  are movable. That is, as shown in Fig. 2, the fixed first lens group  $F_1$ , the second lens group  $F_2$  (zoom lens), the fixed third lens group  $F_3$ , and the fourth lens group  $F_4$  (focusing lens) are arranged in the lens 1. A PN filter 22 and the iris ring 23 are arranged between the second lens group  $F_2$  and the third lens group  $F_3$ . A dummy glass 24 to cut infrared rays is arranged so as to face the fourth lens group  $F_4$ . In the lens 1 with the construction of the inner focusing lens as mentioned above, a focusing ring and a zoom ring are unnecessary and the optical system can be miniaturized.

According to an embodiment of the invention, the fourth lens group  $F_4$  is controlled in the following manner.

An evaluation value which is formed from the integrated level of the middle and high frequency components in the image pickup signal is generated from the optical detector 13. The evaluation value is set to an evaluation value when executing an automatic focusing control. Since the integrated level of the middle and high frequency components in the image pickup signal is maximum at the in-focus position, the lens

position at which the evaluation value has a peak value corresponds to the in-focus position.

A driving signal is given from the system controller 14 to the focusing motor 6 through the driver 15, thereby moving the fourth lens group  $F_4$  toward the infocus position. At the same time, the peak value of the evaluation values sent from the optical detector 13 is detected. The fourth lens group  $F_4$  is position controlled to the position at which the evaluation value has the peak value.

The fourth lens group  $F_4$  is oscillated in the front and back directions so as to follow the motion of an object to be photographed. In the case where the second lens group  $F_2$  is not moved in a fixed zoom mode, front and back oscillating amounts of the fourth lens group  $F_4$  at this time are equal. As mentioned above, the evaluation values are detected while oscillating the fourth lens group  $F_4$ . Due to this, the position of the fourth lens group  $F_4$  is controlled in accordance with the motion of the object to be photographed.

In the case of changing the zoom amount, a driving signal is supplied from the system controller 14 to the second lens group  $F_2$  through a driver 17. Due to this, the second lens group  $F_2$  is moved. The position of the second lens group  $F_2$  at this time is detected by the zoom position detector 3 and the position detection information is given to the system controller 14. At the same time, oscillating amount data is read out of the oscillating-amount memory 21 in correspondence to the movement of the second lens group  $F_2$ . The front and back oscillating amount is changed on the basis of the oscillating amount data, thereby oscillating the fourth lens group  $F_4$ . The evaluation values are detected while oscillating the fourth lens group  $F_4$  by changing the oscillating amount in the front and back directions. Due to this, the position of the fourth lens group  $F_4$  is controlled in accordance with the motion of the object to be photographed. The position of the fourth lens group  $F_4$  is controlled so as to follow the motion of the second lens group  $F_2$  in a manner such that a focal point does not deviate when the zoom amount is changed.

As mentioned above, according to an embodiment of the invention, in the case of changing the zoom amount, by changing the front and back oscillating amounts of the fourth lens group  $F_4$  on the basis of the oscillating amount data from the oscillating-amount memory 21, oscillating control and a tracking control can be simultaneous performed.

That is, Fig. 3 shows the relation between the position of the second lens group  $F_2$  and the position of the fourth lens group  $F_4$  as an in-focus position in the lens 1. In Fig. 3, a line  $B_1$  indicates the position of the fourth lens group  $F_4$  serving as an in-focus position when the second lens group  $F_2$  has been moved along a line  $A_1$  for an object existing at an infinite remote position. A line  $B_2$  indicates the position of the fourth lens group  $F_4$  serving as an in-focus position

when the second lens group  $F_2$  has been moved along the line  $A_1$  in an object existing at a predetermined distance  $LA$  (for example, 90 cm). In the case of the object existing between the above two positions, a characteristic line indicative of the position of the fourth lens group  $F_4$  which is set to an in-focus position when the second lens group  $F_2$  has been moved along the line  $A_1$  can be drawn in a hatched region between the lines  $B_1$  and  $B_2$ . When the second lens group  $F_2$  has been moved along the line  $A_1$ , by moving the fourth lens group  $F_4$  along predetermined lines  $B_1$  to  $B_2$ , the infocus position can be held.

When the second lens group  $F_2$  is moved, it is necessary to control so as to oscillate the fourth lens group  $F_4$  back and forth so as to follow the motion of the object together with such a tracking control.

It is difficult to simultaneously perform the tracking control and the oscillating control. Therefore, according to the embodiment of the invention, by making the front and back oscillating amounts variable, a process which is equivalent to that the tracking control and the oscillating control are simultaneously executed can be performed.

That is, the process to oscillate the fourth lens group  $F_4$  in the front and back directions is shown by a vector  $P$  and a vector  $Q$  whose lengths are equal and whose directions are opposite as shown in Fig. 4A. The process for tracking the fourth lens group  $F_4$  in accordance with the motion of the second lens group  $F_2$  is shown by a vector  $R$  along a characteristic curve of the positional relation of the fourth lens group  $F_4$  serving as an infocus position when the second lens group  $F_2$  has been moved as shown in Fig. 4B. Thus, the process when the tracking control and the oscillating control have simultaneously executed is as shown in Fig. 4C.

The vector  $R$  can be separated into vectors  $R_1$  and  $R_2$  as shown in Fig. 4D.

$$R_1 = R \cos \Theta$$

As shown in Fig. 4E, therefore, when the fourth lens group  $F_4$  is oscillated by a vector  $(P - R_1)$  which is obtained by subtracting the vector  $R_1$  from the vector  $P$  and a vector  $(Q + R_1)$  which is obtained by adding the vector  $Q$  and the vector  $R_1$ , a process which is equivalent to that the tracking control and the oscillating control have simultaneously executed is performed.

In Fig. 1, the oscillating amount data of the fourth lens group  $F_4$  corresponding to the movement amounts of the second lens group  $F_2$  at every position of the object is stored into the oscillating-amount memory 21. When the second lens group  $F_2$  is moved, the oscillating amount data is read out of the oscillating amount memory 21 in accordance with the movement of the second lens group  $F_2$ . On the basis of the oscillating amount data, the fourth lens group  $F_4$  is oscillated in the front and back directions. Due to this, the tracking control and the oscillating control are sim-

ultaneously executed.

According to the invention, when the second lens group  $F_2$  (zoom lens) is moved, by oscillating the second lens group  $F_2$  by changing the movement amount in the front direction and the movement amount in the back direction in accordance with the relation between the position of the second lens group  $F_2$  and the in-focus position of the fourth lens group  $F_4$ , the process which is equivalent to the oscillating control is executed simultaneously with the execution of the tracking control can be performed. Such a control can be realized by a process similar to an ordinary automatic focusing. Therefore, when the zoom amount is changed, the tracking control and the oscillating control can be performed without executing any complicated processes.

## Claims

1. A zoom tracking apparatus for a focusing lens in which a position of a focusing lens ( $F_4$ ) is controlled to an in-focus position so as to follow a motion of a zoom lens ( $F_2$ ), comprising:
  - means (15,6) for oscillating the focusing lens ( $F_4$ ) or an image pickup device forwards and backwards;
  - characterized by:
    - means (14) for controlling the forward and backward oscillating amounts of the focusing lens ( $F_4$ ) or the image pickup device and changing them in accordance with a relation between the position of the zoom lens ( $F_2$ ) and the in-focus position of the focusing lens ( $F_4$ ).
2. A zoom tracking apparatus according to claim 1, wherein said focusing lens ( $F_4$ ) and zoom lens ( $F_2$ ) are included in a first ( $F_1$ ), a second ( $F_2$ ), a third ( $F_3$ ) and a fourth ( $F_4$ ) lens group, counting from the photographed object side.
3. A zoom tracking apparatus according to claim 2, wherein said second ( $F_2$ ) and fourth ( $F_4$ ) lens groups are movable.
4. A zoom tracking apparatus according to claim 3, wherein said second lens group ( $F_2$ ) comprises a zoom lens and said fourth lens group ( $F_4$ ) comprises a focusing lens.
5. A zoom tracking apparatus according to any one of the preceding claims, wherein said focusing lens ( $F_4$ ) is controlled on the basis of the oscillating amount for tracking control and the moving amount for focusing control.
6. A zoom tracking apparatus according to any one of the preceding claims, further comprising a memory (21) for storing the oscillating amount, the oscillating amount being controlled on the basis of the information within the memory (21).
7. A zoom tracking apparatus according to claim 6, wherein said memory (21) stores the data for compensating the focusing position corresponding to the movement of the zoom lens ( $F_2$ ) and the oscillating control and the tracking control are executed simultaneously by controlling the movement of said fourth lens group ( $F_4$ ).
8. A video camera including zoom tracking apparatus according to any one of the preceding claims.

Fig. 1A

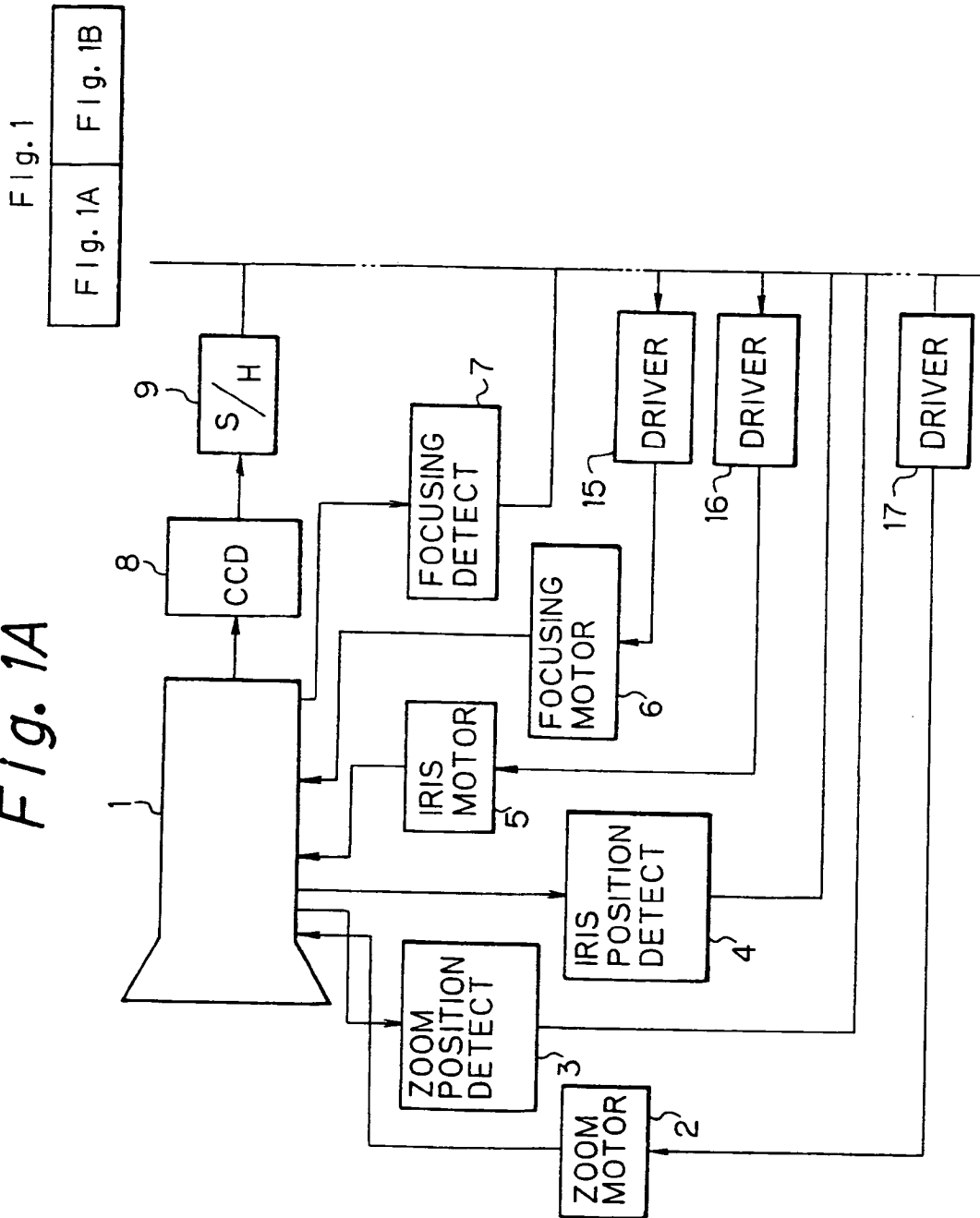


Fig. 1B

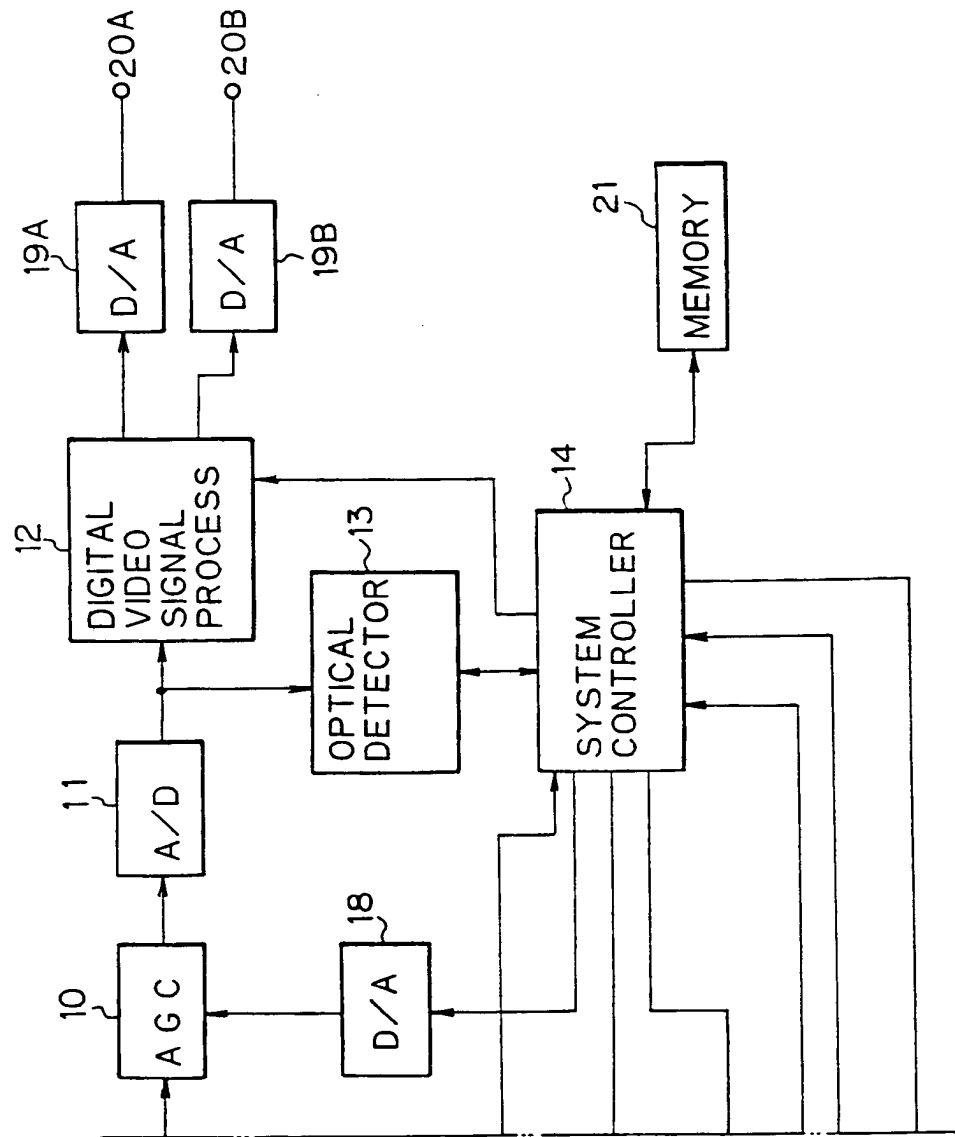


Fig. 2

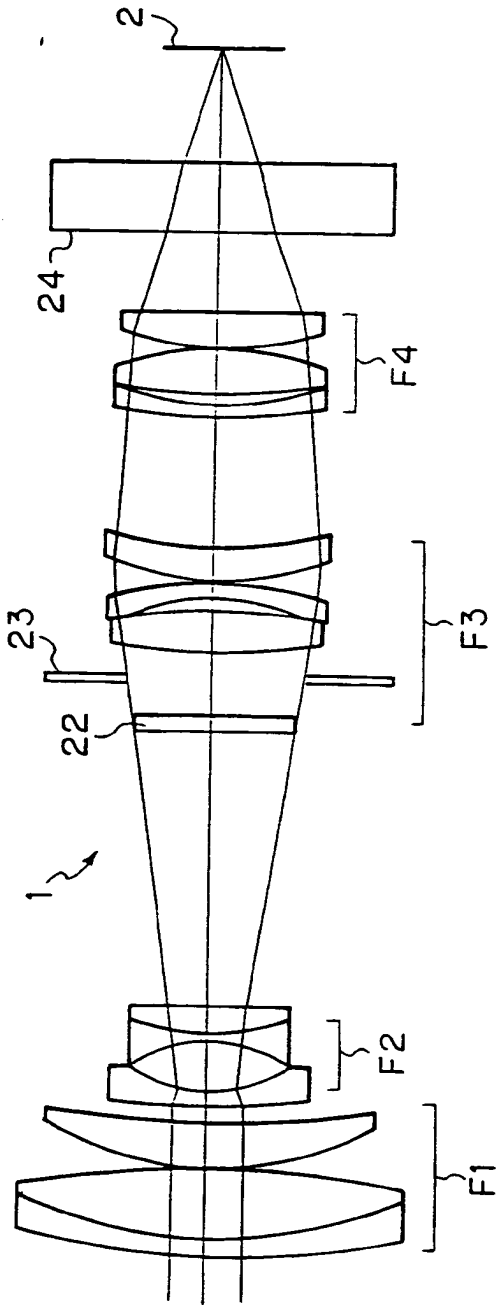
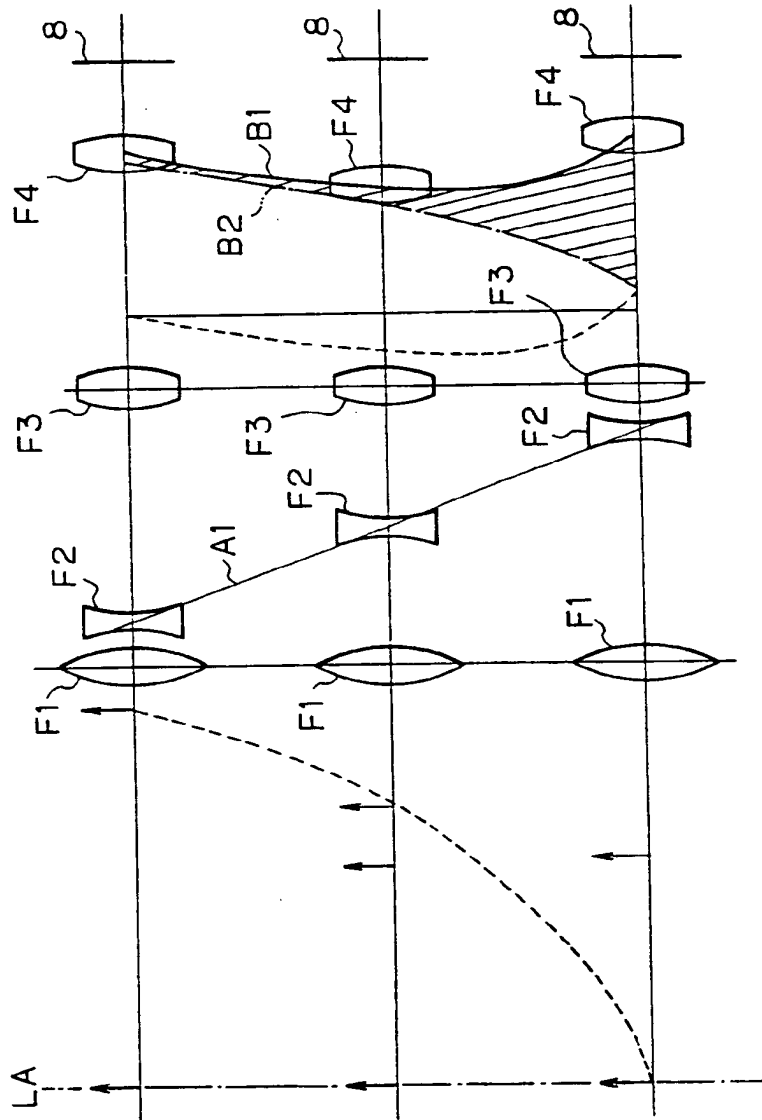
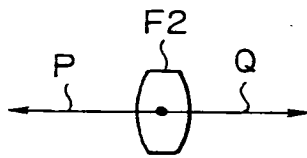


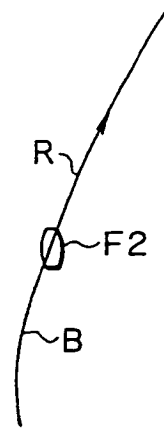
Fig. 3



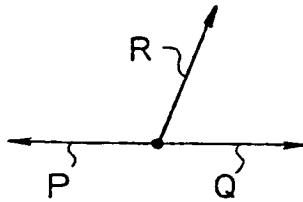
*Fig. 4A*



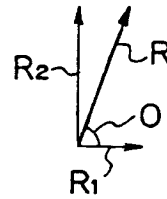
*Fig. 4B*



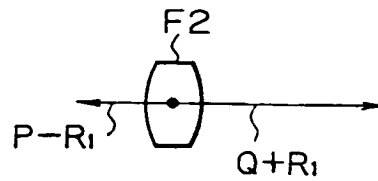
*Fig. 4C*



*Fig. 4D*



*Fig. 4E*





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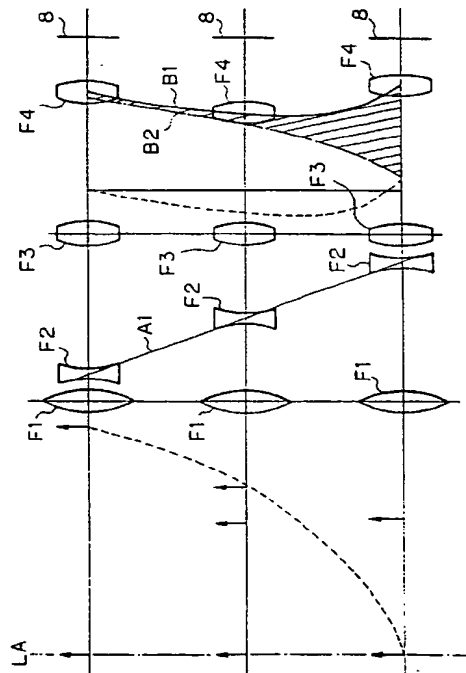
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*Fig. 3*





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# EUROPEAN SEARCH REPORT

Application Number

EP 91 31 0210

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. CL.5)
P, X	EP-A-0 407 914 (CANON KABUSHIKI KAISHA) * the whole document *	1, 6-8	G02B7/28 G02B7/10 H04N5/232
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 98 (P-840) 8 March 1989 & JP-A-63 280 208 ( HITACHI LTD ) 17 November 1988 * abstract *	1	
A	DE-A-3 217 884 (HITACHI LTD) * page 12, paragraph 1 - page 14, paragraph 3; claims 2, 3, 8, 10, 13; figures 1-3 *	1-4, 6	
A	EP-A-0 394 901 (CANON KABUSHIKI KAISHA) * column 1, line 45 - column 2, line 47; claims 1-4, 21-25; figures 2-5 *	1, 6-8	
A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 15 (P-536) 16 January 1987 & JP-A-61 190 309 ( MATSUSHITA ELECTRIC IND CO LTD ) 25 August 1986 * abstract *	1	
			TECHNICAL FIELDS SEARCHED (Int. CL.5)
			G02B H04N
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 19 JUNE 1992	Examiner M. SCHEU
<p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons</p> <p>&amp; : member of the same patent family, corresponding document</p>			

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